scattered while the light of polarization B will remain unscattered. The camera **2530** has an infrared linear polarizer **2545** immediately in front of it; this polarizer **2545** absorbs light of polarization A and transmits light of polarization B. Thus, camera **2530** only views light of polarization B, which was left unscattered by scattering polarizer **2545**. This gives camera **2530** a clear, high-contrast image of the area in front of the screen.

[**0225**] Using Prismatic Films

[**0226**] In interactive projected window displays in general, it is often desirable to have the area under the window display clear, but position the camera so that the area it views slopes upward. This situation can be achieved with the use of prismatic films that redirect all light that pass through them by a specific angle. For examples, the Vikuiti IDF film made by 3M redirects incoming light by 20 degrees. By placing one or more of these films on either side of the projection screen to redirect light upward, the camera can be placed higher relative to the screen, as shown in **FIG. 26**.

[**0227**] Compaction

[**0228**] The overall size of the system can be compacted using a mirror. **FIG. 27** shows a configuration in which the camera and projector are placed next to the window, pointing away from it, and a mirror reflects their light beams back toward the window.

[**0229**] Camera Improvements

[**0230**] For further image quality improvement and ambient light rejection, the camera and camera's illuminators can be strobed together. This approach is fully compatible with the use of various software and hardware approaches for 3D imaging. In particular, the camera and illuminator in this design can be replaced with a time-of-flight camera.

[**0231**] Visible Light System

[**0232**] If no linear polarizers are added next to the scattering polarizer (as shown in **FIG. 25**), then the design does not require the use of an infrared camera. A color or black-and-white visible light camera is able to image the area in front of the screen, so long as there is a visible-light linear polarizer immediately in front of the camera, with the polarization direction parallel to the direction for which the scattering polarizer is transparent. Thus, the projected image is unseen by the camera, allowing the camera to see the area in front of the screen unimpeded. This camera can work either with the existing ambient light or with additional visible lights placed near the display to illuminate users and objects in front of the screen. If additional visible lights are added, the camera and lights may be strobed together, as described in the section of the present application entitled "Directional Ambient Infrared" to improve the quality of the camera's images and limit the effects of ambient and projector light on the image.

[**0233**] For further image quality improvement, a high-speed aperture can be placed in front of the projector's lens. This aperture may be mechanical or electronic; one available electronic aperture is the liquid-crystal-based Velocity Shutter, produced by Meadowlark Optics. In one embodiment, this shutter remains open nearly all of the time, allowing the projector light to pass through. The shutter only closes to block the projector's light while the camera is taking a picture. If the camera's exposure time is brief, then the brightness of the projector will be almost unaffected. Note that the use of a velocity shutter to block the projector's light during the camera's exposure also allows a visible-light camera to be used in front projected interactive floor or wall displays.

[**0234**] Note that with the use of a visible-light camera in an interactive video projection system, a real-time picture of the people in front of the screen (the system's users) is obtained in addition to a vision signal classifying each pixel of the camera's image as foreground or background. This allows the vision system to isolate a picture of the system's users with the static background removed. This information allows the system to place a color image of the users in the image it displays, with artificially generated images inserted on and around the users. If this system is properly calibrated, a user could touch the screen, and the displayed image of the user would touch the same location on the screen at the same time. These features provide significant improvement in the quality of interactive applications running on this display including, for example, allowing users to literally see themselves placed inside the interactive content.

[**0235**] The visible-light image from the camera can be used to create a virtual mirror, which looks and behaves like a real mirror, but the mirror image can be electronically manipulated. For example, the image could be flipped horizontally to create a non-reversing mirror, in which users see an image of themselves as other people see them. Alternatively, the image could be time-delayed so that people could turn around to see their own backs. This system could thus have applications in environments where mirrors are used including, for example, dressing rooms.

[**0236**] Time-of-Flight Camera Interactive Display

[**0237**] Embodiments of the present invention may be implemented using time-of-flight cameras. A time-of-flight camera has a built-in capability to detect distance information for each pixel of its image. Using a time-of-flight camera eliminates the need for a modified display. In other words, the time-of-flight camera may work with any display (e.g., an LCD panel, a cathode-ray tube display, etc.) without modifications. A single time-of-flight camera may be used. However, a single time-of-flight camera may not be able to detect objects that are blocked by objects closer to the camera. Therefore, embodiments of the present invention utilize multiple time-of-flight cameras, as shown in **FIG. 28**.

[**0238**] With redundancy of cameras, there is no longer a need to worry about one camera not being able to detect al the objects because of one object occluding another object. For example, as shown in **FIG. 29**, four time-of-flight cameras may be placed at the corners of a display, ensuring that the entire area of the display is interactive. In order to use this time-of-flight implementation for multiple cameras, a coordinated transform is performed on each pixel of each time-of-flight camera to put it in a common coordinate space. One such space is defined by: (x, y)—the position of the point projected perpendicular onto the display surface, and (z)—the distance from the display. This coordinate space transformation can be determined by looking at the angle of each camera (and position) relative to the screen. Alternatively, the transformation may be determined by a calibration process, in which an object of known size, shape and position is placed in front of the screen. By having each of the cameras image the object, the appropriate transformation function can be determined from points viewed by each camera into points in the common coordinate space. If the camera coordinate transforms are done in real time, then a real-time picture of the area in front of the camera in 3D is achieved.